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**PATENT**

**CERTIFICATE OF MAILING PURSUANT TO 37 CFR § 1.8**

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11/2/04

Date

Michelle Hobson

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**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In Re Application of:

TEOH & WALLACE

Serial No.: 10/634,176

Filing Date: August 4, 2003

Title: NON-OVERLAPPING SPHERICAL THREE-DIMENSIONAL COIL

Examiner: U. Ho

Group Art Unit: 3731

Confirmation No.: 7120

Customer No.: 20855

**TRANSMITTAL LETTER**

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Sir:

Transmitted herewith for filing, please find the following documents:

x Brief on Appeal with attached Appendix A and B (21 pages) *in triplicate*

x Return receipt postcard.

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The fee is calculated as follows:

	NO. OF CLAIMS	CLAIMS PREVIOUSLY PAID FOR	EXTRA CLAIMS	RATE	FEE
Total Claims	23	- 23	0	x \$18.00	\$0
Independent Claims	2	- 3	0	x \$88.00	\$0
Multiple dependent claims not previously presented, add \$300.00					\$0
Total Amendment Fee					\$0
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x A check in the amount of \$340.00 is enclosed.

The Commissioner is hereby authorized to charge any appropriate fees under 37 C.F.R. §§1.16, 1.17, and 1.21 that may be required by this paper, and to credit any overpayment, to Deposit Account No. 18-1648.

Respectfully submitted,

Date: November 2, 2004

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Filing Date: August 4, 2003	Customer No.: 20855
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**BRIEF ON APPEAL**

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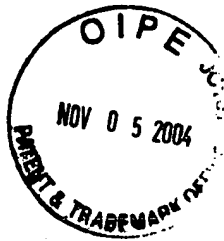
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**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In Re Application of:

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Serial No.: 10/634,176

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**BRIEF ON APPEAL**

Mail Stop Appeal Brief  
Commissioner for Patents  
Alexandria, VA 22313

Sir:

**INTRODUCTION**

Appellants submit in triplicate their brief on appeal in accordance with 37 C.F.R. §1.192. All claims were finally rejected under 35 U.S.C. § 112, first and second paragraphs, as well as under 35 U.S.C. § 102. The specification was also objected to as allegedly confusing and containing new drawings. A Notice of Appeal was filed October 4, 2004, making a Brief on Appeal due on or before December 4, 2004. Accordingly, this Brief is timely filed. Appellants respectfully request that the decision of the Examiner be reversed.

### **I. REAL PARTIES IN INTEREST**

Scimed Life Systems, Inc., a division of Boston Scientific Corporation, is the real party in interest in this matter.

### **II. RELATED APPEALS AND INTERFERENCES**

Appellants are not aware of any related appeals or interferences.

### **III. STATUS OF THE CLAIMS**

Appealed claims 1-23 were originally filed with the above-referenced case (hereinafter "the application") on August 4, 2003. The application is a continuation of U.S. Serial No. 09/691,954, filed October 18, 2000, now U.S. Patent No. 6,635,069. No amendments to the claims have been made and all appealed claims remain rejected under 35 U.S.C. §§ 102 or 103.

### **IV. STATUS OF THE AMENDMENTS**

In response to a request made in the Examiner's first Office Action mailed March 19, 2004, Appellants submitted FIG. 6 and amended the Brief Description of the Drawings. *See*, Amendment mailed on April 19, 2004. In the Final Office Action, mailed on July 12, 2004, the Examiner objected to the description of the drawing. Accordingly, Appellants filed an Amendment after Final amending the Brief Description of FIG. 6. The Advisory Action, mailed on September 8, 2004, indicated the objection to FIG. 6 and the Brief Description of this Figure was overcome by these amendments, but that the rejections of the claims based on the cited reference remained. Thus, the only remaining issue in this case is whether the claims are anticipated or obvious in view of the cited reference.

## **V. SUMMARY OF THE CLAIMS**

The claims relate generally to vaso-occlusive devices (page 1, lines 3-6). The devices have a relaxed three-dimensional configuration that is made up of a plurality of non-overlapping loops (page 1, lines 3-6). By "non-overlapping" is meant a structure in which the loops formed by the wire making up the device's three-dimensional configuration do not cross back over themselves (page 5, lines 7-13, FIG. 5). Advantages of non-overlapping designs include reducing rotation and whipping upon deployment (page 5, lines 15-19).

Thus, claims relate to a vaso-occlusive device comprising at least one substantially linear strand of a vaso-occlusive member (page 3, lines 10-11). The linear member is wound into a stable, three-dimensional relaxed configuration (page 3, lines 11-12; page 10, lines 22-24) comprising a plurality of non-overlapping loops (page 3, line 12). The relaxed (non-overlapping) configuration self-forms upon release from a restraining member (page 3, line 13). The relaxed configuration can approximate a sphere (page 3, line 15). Furthermore, the relaxed configuration of the devices of the claims may comprise between 6 and 20 loops (page 3, line 17) or between 6 and 12 loops (page 3, line 18).

The vaso-occlusive member may comprise a metal selected from the group consisting of platinum, palladium, rhodium, gold, tungsten and alloys thereof (page 3, lines 18-20). This member may also comprise a stainless steel, a super-elastic metal alloy or nitinol (page 3, lines 20-22).

In certain embodiments, the vaso-occlusive member may further comprise additional filamentary material attached thereto (page 3, lines 23-24) and/or a deployment tip attached to at least one of the two ends of the vaso-occlusive member (page 3, lines 24-26). The deployment tip can comprise a mechanically detachable end adapted to attach and detach from a pusher or an electrolytically detachable end adapted to detach from a pusher by imposition of a current on the pusher (page 3, lines 27-29).

The claims also relate to methods of occluding a body cavity by introducing any of these devices into the body cavity, for example, an aneurysm (page 4, lines 1-3).

Methods of method of making the non-overlapping three-dimensional vaso-occlusive devices are also claimed, the methods generally involving (a) winding a substantially linear strand of a vaso-occlusive member around a winding mandrel, where the pattern of winding

produces a non-overlapping a three-dimensional vaso-occlusive device as described herein (page 4, lines 4-9); and (b) heating the mandrel and vaso-occlusive member to produce said vaso-occlusive device (page 4, lines 4-9). The winding pattern may be, for example, a Figure 8 or hourglass pattern (page 4, lines 10-11). The winding mandrel may be, for example, a sphere having grooves adapted to fit the substantially linear strand (page 4, lines 13-14), a cylinder (page 4, line 12), a sphere having a plurality of pins on its surface (page 4, lines 13-14), or a tetrahedron (page 4, line 12). In certain embodiments, the winding mandrel comprises 3 intersecting posts that form a 6-post structure, each post being at approximately 90 relative to the adjacent posts (page 4, lines 14-18). The posts of any of these mandrels may have a round cross section (page 4, lines 14-18).

#### **VI. ISSUES ON APPEAL**

1. Whether pending claims 1-8 and 10-23 are anticipated by U.S. Patent No. 6,638,291 under 35 U.S.C. § 102(e).
2. Whether pending claim 9 is obvious over U.S. Patent No. 6,638,291 under 35 U.S.C. § 103(a).

#### **VII. GROUPING OF CLAIMS**

Claims 1-23 are separately patentable, enabled and described by the application as filed. Therefore, these claims are divided into 23 separate groups:

(1) Claim 1: Independent claim 1 is directed to a vaso-occlusive device comprising at least one substantially linear strand of a vaso-occlusive member wound into a stable, three-dimensional relaxed configuration. The relaxed configuration self-forms upon release from a restraining member. Furthermore, the stable, three-dimensional relaxed configuration comprises a plurality of non-overlapping loops.



(2) Claim 2: Claim 2 is directed to the vaso-occlusive device of claim 1 and further specifies that the relaxed configuration fills a body cavity.

(3) Claim 3: Claim 3 is directed to the vaso-occlusive device of claim 1 and further specifies that the relaxed configuration approximates a sphere.

(4) Claim 4: Claim 4 is directed to the vaso-occlusive device of claim 1 and further specifies that there are between 6 and 20 non-overlapping loops.

(5) Claim 5: Claim 5 is directed to the vaso-occlusive device of claim 1 and further specifies that there are between 6 and 12 non-overlapping loops.

(6) Claim 6: Claim 6 is directed to the vaso-occlusive device of claim 1 and further specifies that the vaso-occlusive member comprises a metal selected from the group consisting of platinum, palladium, rhodium, gold, tungsten and alloys thereof.

(7) Claim 7: Claim 7 is directed to the vaso-occlusive device of claim 1 and further specifies that the vaso-occlusive member comprises a stainless steel or super-elastic metal alloy.

(8) Claim 8: Claim 8 is directed to the vaso-occlusive device of claim 1 and further specifies that the vaso-occlusive member comprises nitinol.

(9) Claim 9: Claim 9 is directed to the vaso-occlusive device of claim 1 and further specifies that additional filamentary material is attached to the vaso-occlusive member.

(10) Claim 10: Claim 10 is directed to the vaso-occlusive device of claim 1 and further specifies that a deployment tip is attached to at least one of the two ends of the vaso-occlusive member.

(11) Claim 11: Claim 11 is directed to the vaso-occlusive device of claim 10 and further specifies that the deployment tip comprises a mechanically detachable end adapted to attach and detach from a pusher.

(12) Claim 12: Claim 12 is directed to the vaso-occlusive device of claim 10 and further specifies that the deployment tip comprises an electrolytically detachable end adapted to detach from a pusher by imposition of a current on the pusher.

(13) Claim 13: Claim 13 is directed to a method of occluding a body cavity, the method comprising introducing a vaso-occlusive device according to claim 1 into the body cavity.

(14) Claim 14: Claim 14 is directed to the method of claim 13 and further specifies that the body cavity is an aneurysm.

(15) Claim 15: Claim 15 is directed to a method of making a non-overlapping three-dimensional vaso-occlusive device according to claim 1, the method comprising (a) winding a substantially linear strand of a vaso-occlusive member around a winding mandrel in a winding pattern that produces a non-overlapping three-dimensional vaso-occlusive device; and (b) heating the mandrel and vaso-occlusive member to produce the vaso-occlusive device.

(16) Claim 16: Claim 16 is directed to the method of claim 15 and further specifies that the winding pattern is a Figure 8 or hourglass pattern.

(17) Claim 17: Claim 17 is directed to the method of claim 15 and further specifies that the winding mandrel comprises a sphere having grooves adapted to fit the substantially linear strand.

(18) Claim 18: Claim 18 is directed to the method of claim 15 and further specifies that the winding mandrel comprises a cylinder.

(19) Claim 19: Claim 19 is directed to the method of claim 15 and further specifies that the winding mandrel comprises a sphere having a plurality of pins on the surface thereof.

(20) Claim 20: Claim 20 is directed to the method of claim 15 and further specifies that the winding mandrel is a tetrahedron.

(21) Claim 21: Claim 21 is directed to the method of claim 15 and further specifies that the winding mandrel comprises 3 intersecting posts which form a 6 post structure and, in addition, that each post of this mandrel is at approximately 90 relative to the adjacent posts.

(22) Claim 22: Claim 22 is directed to the method of claim 21 and further specifies that at least one post has a round cross section.

(23) Claim 23: Claim 23 is directed to the method of claim 21 and further specifies that each post has a round cross section.

## **VIII. ARGUMENTS**

### **1. Anticipation Has Not Been Established**

In the Final Office Action, the Examiner rejected claims 1-8 and 10-23 as allegedly anticipated by U.S. Patent No. 6,638,291 (hereinafter "Ferrera"). With particular references to Figs. 2-3B, it was again alleged that Ferrera discloses a device having non-overlapping loops in its relaxed configuration. (Final Office Action, paragraph 3). In response to Appellants' previous arguments, the Examiner stated, "the device as claimed [has] the same overlapping configuration as indicated by the applicant shown in figure 2 above." (Final Office Action, paragraph 6).

In order to establish that a single reference anticipates the claims, the Examiner bears the burden of showing that each and every element of the claims is described within the four corners of the reference. *Lindemann Maschinenfabrik GMBH v. American Hoist & Derrick*, 221 USPQ 481, 485-86 (Fed. Cir. 1984). There must be no difference between the claimed invention and

the reference disclosure, as viewed by a person of ordinary skill in the field of the invention.

*Scripps Clinic & Research Foundation v. Genentech, Inc.*, 18 USPQ2d 1896 (Fed. Cir. 1991).

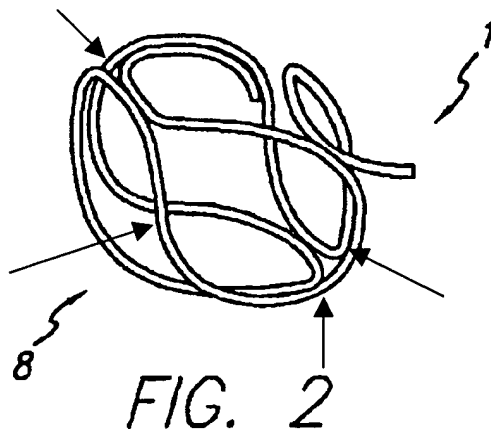
In the pending case, the Examiner has not met this burden. Anticipation of the pending claims by Ferrera has not been (and indeed cannot be) established.

(a) Ferrera Does Not Disclose Each and Every Element of the Pending Claims but, in fact, Discloses Only Orthogonal (Intersecting) Configurations

The Examiner has improperly interpreted the Figures of Ferrera in imposing a rejection of claims 1-8 and 10-23 based on § 102(e). Simply put, Ferrera doesn't disclose vaso-occlusive devices in which the loops making up the device do not overlap and, indeed, teaches that the devices have "orthogonal" (*i.e.*, intersecting) configurations.

Appellants appreciate the difficulty of capturing a three-dimensional device in a two-dimensional drawing. As will be apparent, this difficulty is compounded when one tries to describe a three-dimensional device with words.

To overcome these difficulties, Appellants first showed the overlapping nature of Ferrera's loops by adding added arrows to the device shown in FIG. 2 of Ferrera (see, page 5 of Response to Office Action, mailed on April 19, 2004):



The arrows added to FIG. 2 of Ferrera point to areas that overlap when viewed face-on in three dimensions (instead of from the side as necessarily viewed in a two-dimension representation).

In response, the Examiner presented Appellants own FIG. 5 with similarly placed arrows. However, Appellants note again that the arrows added by the Examiner to their FIG. 5 point to areas that appear to overlap only because of the inherent inability of two-dimensional representations to depict depth three-dimensional structure. In other words, the arrows added by the Examiner point to loops, which when viewed face-on in three dimensions (instead of from side in two-dimensions) are actually as far apart and, are non-intersecting. If one were to rotate the device shown in FIG. 5 one quarter of a turn on it's axis, the Figure would look virtually identical -- each "side" of the three-dimensional device has the C-shaped loop shown facing the viewer in FIG. 5. This is not the case with Ferrera, which, when rotated, would clearly show the overlapping nature of the component loops.

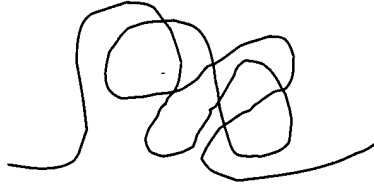
Appellants next attempted to illustrate the overlapping nature of Ferrera's device by inviting the Examiner to trace a path along the wires making up the loops of three-dimensional structures. In other words, the contour of the device was depicted in two dimensions to show whether strands overlap. Tracing such a path of the C-shaped loops making up the device shown in FIG. 5 of Appellants' specification would result in the following path (see, also page 4 of the Appellants' Response After Final, mailed on August 2, 2004):



As can be seen from this exercise, there is no overlap created when following the path taken by the loops of the device shown in FIG. 5. Instead, and as noted above, each loop of the structure shown in FIG. 5 has the shape of the front-view loop shown in the foreground of this figure. There is no overlap with adjacent loop structures.

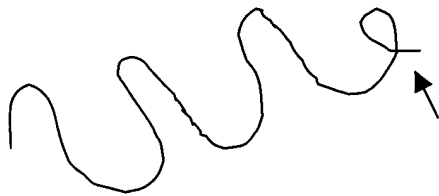
Appellants then conducted the same path-tracing exercise on the device shown in FIG. 2 of Ferrera (see, page 5 of Response After Final, filed August 2, 2004) to show the overlapping

nature of Ferrera's loops. Tracing a path along the loops of Ferrera's device would result in a path looking something like this:



Clearly, Ferrera's loops are overlapping and, accordingly, this reference cannot disclose, expressly or inherently, devices as claimed in which the relaxed configuration is made up of non-overlapping loops.

Nonetheless, and contrary to all evidence of record, the Examiner continued to maintain in the Advisory Action that Ferrera's loops are non-overlapping and that the path-tracing exercise would results in path as follows (see, page of Advisory Action, mailed on September 8, 2004):



This assertion is erroneous. Unlike the claimed devices, Ferrera's loops clearly overlap in multiple locations -- the path-tracing exercise was only a demonstration of this fact.

Furthermore, the Examiner has now acknowledged that Ferrera's loops overlap in at least one location, namely the right most loop of the Examiner's depiction, as can be seen by the arrow above.

Finally, Appellants note that Ferrera, by its own teachings, describes only devices containing intersecting loops. In particular, at col. 6, lines 2-5, Ferrera describes the embodiment shown in FIG. 2 of the reference as follows (emphasis added):

As is illustrated in FIG. 2, in a presently preferred embodiment, the three dimensional portion of the vasoocclusive device is orthogonal...

Merriam-Webster's on-line dictionary defines "orthogonal" as "intersecting or lying at right angles ... having perpendicular slopes or tangents at the point of intersection." (See, Appendix B). Quite simply, and in stark contrast to the claimed devices, Ferrera teaches explicitly that their devices comprise structures have overlapping (intersecting) loops.

Thus, given the evidence of record, including Ferrera's own teachings, the Examiner's admission, Appellants' textual explanations of three-dimensional structures and description of a simple, path-tracing exercise that can be readily repeated again and again to give the same results, the rejection is entirely unsustainable. Ferrera does not describe or demonstrate a device as claimed, in which the loops making up the three-dimensional configuration do not overlap and, accordingly, this reference cannot anticipate any of the pending claims.

## **2. *Prima Facie* Obviousness Has Not Been Established**

Claim 9 is patentable over Ferrera because, for the reason described above, there is no teaching, suggestion or motivation within Ferrera to arrive at devices comprising non-overlapping loops. In fact, for the reasons noted above, Ferrera teaches away from the claimed subject matter.

In sum, Ferrera does not teach or suggest devices comprising non-overlapping loops as recited in the appealed claims. The components and characteristics of the claimed devices are precisely defined -- in the claims themselves, not in Ferrera or by the Examiner. Ferrera does not teach or suggest non-overlapping loop structures. Therefore, Appellants respectfully request that the rejection of these claims as allegedly obvious over the cited reference be withdrawn, and that these claims be allowed.

## **3. While *Prima Facie* Obviousness Has Not Been Established, Additional Factual Evidence Of Record Further Supports The Nonobviousness Of The Claimed Methods**

As discussed above and during prosecution of this application, the Examiner has not established the *prima facie* obviousness of the claimed methods because Ferrera does not teach or suggest devices having non-overlapping loops or methods of making or using these devices.

Since no *prima facie* case has been established, Appellants have no burden of coming forward with evidence positively establishing nonobviousness. *See, e.g., In re Rinehart* 189 USPQ 143 (CCPA 1976).

However, additional scientific evidence is in fact of record in the present case and that additional evidence further supports the nonobviousness of the presently claimed subject matter. For example, it is clear from the factual record that non-overlapping loop structures impart several functional advantages over known devices. As described in the specification (see, page 5, lines 15-19; page 5, line 27 to page 6, line 14; and page 7, lines 5-9):

Advantages of the present invention include, but are not limited to, (i) reducing or eliminating rotation upon deployment; (ii) reducing or eliminating whipping upon deployment; (iii) providing vaso-occlusive devices that readily and substantially conform to fill a target vessel in a relaxed configuration; and (iv) providing methods and materials for making these non-overlapping vaso-occlusive devices. ...

The non-overlapping loop design described herein provides an improvement over known devices, for example in terms of ease of deployment. Available three-dimensional coils are made up of a plurality of overlapping and intertwined loops. Upon deployment from a substantially linear configuration these devices often rotate or whip undesirably during deployment. Whipping refers to the phenomena where a device stores energy imparted by a user and then releases the energy very quickly. For example, vaso-occlusive devices are often deployed and manipulated at the target site using a guidewire controlled by the operator at a proximal location. Whipping occurs when the rotation imparted by the operator on the guidewire does not result in the same 1:1 rotation of the distal end of the device. Rather, the device stores up the rotational energy and then may suddenly release the energy and rotate suddenly in a short time. Rotation, whipping and other problems associated with available vaso-occlusive devices can impede formation of the three-dimensional relaxed configuration. In contrast, the non-overlapping configuration of the devices described minimizes rotation and whipping upon deployment and promotes formation of a three-dimensional configuration that substantially conforms to the target vessel. ...

The non-overlapping devices described herein promote formation of a three-dimensional structure while minimizing rotation and whipping upon deployment. Thus, depending on the winding pattern and mandrel, the coil will readily self-form into its secondary, three-dimensional configuration and, accordingly, can be more easily deployed into a body cavity by the user.



In summary, although a *prima facie* case of obviousness has not been made out (and indeed the reference contain no supporting basis and actually teaches away from the claimed subject matter), additional factual evidence or record in the present case lends even further support to the nonobviousness of the claimed methods.

#### **4. Additional Arguments Regarding Separately Grouped Claims**


Each one of the preceding arguments is applicable to all of the separately grouped claims, *i.e.*, to each claim individually. For the sake of brevity, the arguments have been set out primarily as to independent claim 1. Claims 1-23 contain all the elements of claim 1 and are, therefore, patentable over the cited reference for the reasons discussed in detail above. The dependent claims are also further limited in ways that are neither described nor suggested by the cited references, namely by further defining the elements of the vaso-occlusive device or methods of making and using the device. The Examiner has not adequately explained why these claims are considered unpatentable over Ferrera.

**CONCLUSION**

Applicants submit that the claims are in condition for allowance and request early notification to that effect. If the Examiner has any further issues or wishes to discuss any of the foregoing, she is invited to contact Applicants' undersigned attorney at the telephone number listed below.

Respectfully submitted,

Date: November 2, 2004

By:   
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**APPENDIX A**  
**LIST OF CLAIMS ON APPEAL**

1. (original): A vaso-occlusive device comprising at least one substantially linear strand of a vaso-occlusive member wound into a stable, three-dimensional relaxed configuration comprising a plurality of non-overlapping loops, wherein said relaxed configuration self-forms upon release from a restraining member.

2. (original): The vaso-occlusive device of claim 1, wherein the relaxed configuration fills a body cavity.

3. (original): The vaso-occlusive device of claim 1, wherein the relaxed configuration approximates a sphere.

4. (original): The vaso-occlusive device of claim 1, comprising between 6 and 20 loops.

5. (original): The vaso-occlusive device of claim 1, comprising between 6 and 12 loops.

6. (original): The vaso-occlusive device of claim 1, wherein the vaso-occlusive member comprises a metal selected from the group consisting of platinum, palladium, rhodium, gold, tungsten and alloys thereof.

7. (original): The vaso-occlusive device of claim 1, wherein the vaso-occlusive member comprises a stainless steel or super-elastic metal alloy.

8. (original): The vaso-occlusive device of claim 1, wherein the vaso-occlusive member comprises nitinol.

9. (original): The vaso-occlusive device of claim 1, further comprising additional filamentary material attached to the vaso-occlusive member.

10. (original): The vaso-occlusive device of claim 1, further comprising a deployment tip attached to at least one of the two ends of the vaso-occlusive member.

11. (original): The vaso-occlusive device of claim 10, wherein the deployment tip comprises a mechanically detachable end adapted to attach and detach from a pusher.

12. (original): The vaso-occlusive device of claim 10, wherein the deployment tip comprises an electrolytically detachable end adapted to detach from a pusher by imposition of a current on the pusher.

13. (original): A method of occluding a body cavity comprising introducing a vaso-occlusive device according to claim 1 into the body cavity.

14. (original): The method of claim 13, wherein the body cavity is an aneurysm.

15. (original): A method of making a non-overlapping three-dimensional vaso-occlusive device according to claim 1, the method comprising

(a) winding a substantially linear strand of a vaso-occlusive member around a winding mandrel, said winding comprising a winding pattern that produces a non-overlapping three-dimensional vaso-occlusive device according to claim 1; and

(b) heating the mandrel and vaso-occlusive member to produce said vaso-occlusive device.

16. (original): The method of claim 15, wherein the winding pattern is a Figure 8 or hourglass.

17. (original): The method of claim 15, wherein the winding mandrel comprises a sphere having grooves adapted to fit the substantially linear strand.

18. (original): The method of claim 15, wherein the winding mandrel comprises a cylinder.


19. (original): The method of claim 15, wherein the winding mandrel comprises a sphere having a plurality of pins on the surface thereof.

20. (original): The method of claim 15, wherein the winding mandrel comprises a tetrahedron.

21. (original): The method of claim 15, wherein the winding mandrel comprises 3 intersecting posts which form a 6 post structure and wherein each post is at approximately 90 relative to the adjacent posts.

22. (original): The method of claim 21, wherein at least one post has a round cross section.


23. (original): The method of claim 21, wherein each post has a round cross section.



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## Merriam-Webster Online Dictionary

One entry found for **orthogonal**.

**Thesaurus**

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**Main Entry:** **or thog o nal**

**Pronunciation:** or- 'thā-g&-n&l

**Function:** *adjective*

**Etymology:** Middle French, from Latin *orthogonius*, from Greek *orthogOnios*, from *orth-* + *gOnia* angle -- more at -**GON**

**1 a :** intersecting or lying at right angles **b :** having perpendicular slopes or tangents at the point of intersection <*orthogonal curves*>

**2 :** having a sum of products or an integral that is zero or sometimes one under specified conditions: as **a** *of real-valued functions* : having the integral of the product of each pair of functions over a specific interval equal to zero **b** *of vectors* : having the scalar product equal to zero **c** *of a square matrix* : having the sum of products of corresponding elements in any two rows or any two columns equal to one if the rows or columns are the same and equal to zero otherwise : having a transpose with which the product equals the identity matrix

**3** *of a linear transformation* : having a matrix that is orthogonal : preserving length and distance

**4 :** composed of mutually orthogonal elements <*an orthogonal basis of a vector space*>

**5 :** statistically independent

- **or thog o nal i ty** /- 'thā-g&- 'na-l&-tE/ *noun*

- **or thog o nal ly** /- 'thā-g&-n&l-E/ *adverb*

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Pronunciation Symbols